Tennessee Science Curriculum Framework

Chemistry I

Course Description

Chemistry is a laboratory science course in which students study the composition of matter and the physical and chemical changes it undergoes. In this course, students use science process skills to investigate the fundamental structure of atoms, the way they combine to form compounds, and the interactions between matter and energy. Students explore chemistry concepts through an inquiry approach.

Chemistry students will study:

- Inquiry
- Technology and Engineering
- Atomic Structure
- Matter and Energy
- Interactions of Matter

Embedded Inquiry

Embedded Conceptual Strand

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question

What tools, skills, knowledge, and dispositions are needed to conduct scientific inquiry?

Course Level Expectations

CLE 3221.Inq.1 Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.

CLE 3221.Inq.2 Design and conduct scientific investigations to explore new phenomena, verify previous results, test how well a theory predicts, and compare opposing theories.

CLE 3221.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3221.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3221.Inq.5 Compare experimental evidence and conclusions with those drawn by others.

CLE 3221.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3221.Inq.1** Trace the historical development of a scientific principle or theory.
- ✓**3221.Inq.2** Identify an answerable question and formulate a hypothesis to guide a scientific investigation.
- ✓**3221.Inq.3** Design a simple experiment including appropriate controls.
- ✓**3221.Inq.4** Perform and understand laboratory procedures directed at testing hypothesis.
- ✓**3221.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3221.Inq.6** Correctly read a thermometer, balance, metric ruler, graduated cylinder, pipette, and burette.
- ✓**3221.Inq.7** Record observations and/or data using correct scientific units and significant figures.
- ✓**3221.Inq.8** Export data into the appropriate form of data presentation (e.g., equation, table, graph, or diagram).
- ✓**3221.Inq.9** Translate data into the correct units and dimension using conversion factors and scientific notation**.**
- ✓**3221.Inq.10** Analyze information in a table, graph or diagram (e.g., compute the mean of a series of values or determine the slope of a line).
- ✓**3221.Inq.11** If accepted values are known, calculate the percent error for an experiment.
- ✓**3221.Inq.12** Determine the accuracy and precision of experimental results.
- ✓**3221.Inq.13** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3221.Inq.14** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3221.Inq.15** Design a model based on the correct hypothesis that can be used for further investigation.

State Performance Indicators

- **SPI 3221 Inq.1** Select a description or scenario that reevaluates and/or extends a scientific finding.
- **SPI 3221 Inq.2** Analyze the components of a properly designed scientific investigation.
- **SPI 3221 Inq.3** Determine appropriate tools to gather precise and accurate data.
- **SPI 3221 Inq.4** Evaluate the accuracy and precision of data.
- **SPI 3221 Inq.5** Defend a conclusion based on scientific evidence.
- **SPI 3221 Inq.6** Determine why a conclusion is free of bias.
- **SPI 3221 Inq.7** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Technology and Engineering

Conceptual Strand

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question

How do science concepts, engineering skills, and applications of technology improve the quality of life?

Course Level Expectations

CLE 3221.T/E.1 Explore the impact of technology on social, political, and economic systems.

CLE 3221.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.

CLE 3221.T/E.3 Explain the relationship between the properties of a material and the use of the material in the application of a technology.

CLE 3221.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.

Checks for Understanding (Formative/Summative Assessment)

✓**3221.1** Select appropriate tools to conduct a scientific inquiry.

✓**3221.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

✓**3221.3** Explore how the unintended consequences of new technologies can impact human and non-human communities.

✓**3221.4** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3221.5** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.

State Performance Indicators

SPI 3221.T/E.1 Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.

SPI 3221.T/E.2 Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.

SPI 3221.T/E.3 Evaluate the overall benefit to cost ratio of a new technology.

SPI 3221.T/E.4 Use design principles to determine if a new technology will improve the quality of life for an intended audience.

Embedded Mathematics

Conceptual Strand

Science applies mathematics to investigate questions, solve problems, and communicate findings.

Guiding Question

What mathematical skills and understandings are needed to successfully investigate chemistry?

Course Level Expectations

CLE 3221.Math.1 Understand the mathematical principles associated with the science of chemistry.

CLE 3221.Math.2 Utilize appropriate mathematical equations and processes to solve chemistry problems.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3221.Math.1** Use a variety of appropriate notations (e.g., exponential, functional, square root).
- ✓**3221.Math.2** Select and apply appropriate methods for computing with real numbers and evaluate the reasonableness of the results.
- ✓**3221.Math.3** Apply algebraic properties, formulas, and relationships to perform operations on real-world problems such as: solving for density, determining the concentration of a solution in a variety of units (ppm, ppb, molarity, molality, and percent composition), calculating heats of reactions and phase changes, and manipulating gas law equations.
- ✓**3221.Math.4** Interpret rates of change from graphical and numerical data (e.g., phase diagrams, solubility graphs, colligative properties, nuclear decay or half-life).
- ✓**3221.Math.5** Analyze graphs to describe the behavior of functions (e.g., concentration of a solution, phase diagrams, solubility graphs, colligative properties, nuclear decay half-life).
- ✓**3221.Math.6** Model real-world phenomena using functions and graphs.
- ✓**3221.Math.7** Apply and interpret algebraic properties in symbolic manipulation (e.g., density, concentration of a solution, chemical equations, effect of volume, temperature or pressure on behavior of a gas, percent composition of elements in a compound, molar mass, number of moles, and molar volume, amount of products or reactants given mole, molarity, volume at STP or mass amounts, heat loss or gain using mass, temperature change and specific heat, and half-life of an isotope)
- ✓**3221.Math.8** Apply and communicate measurement units, concepts and relationships in algebraic problem-solving situations.
- ✓**3221.Math.9** Select appropriate units, scales, and measurement tools for problem situations involving proportional reasoning and dimensional analysis.
- ✓**3221.Math.10** Choose, construct, and analyze appropriate graphical representations for a data set.
- ✓**3221.Math.11** Identify and solve different types of stoichiometry problems (e.g., volume at STP to mass, moles to mass, molarity).
- ✓**3221.Math.12** Calculate the amount of product expected in a lab experience and determine percent yield.
- ✓**3221.Math.13** Convert among the quantities of a substance: mass, number of moles, number of particles, molar volume at STP.

State Performance Indicators

- **SPI 3221.Math.1** Use real numbers to represent real-world applications (e.g., slope, rate of change, probability, and proportionality).
- **SPI 3221.Math.2** Perform operations on algebraic expressions and informally justify the procedures chosen.
- **SPI 3221.Math.3** Interpret graphs that depict real-world phenomena.
- **SPI 3221.Math.4** Apply measurement unit relationships including Avogadro's number, molarity, molality, volume, and mass to balance chemical equations.
- **SPI 3221.Math.5** Use concepts of mass, length, area, and volume to estimate and solve real-world problems.

Standard 1 – Atomic Structure

Conceptual Strand 1

Atomic theory is the foundation for understanding the interactions and changes in matter.

Guiding Question 1

How does the structure of matter determine its chemical and physical properties?

Course Level Expectations

CLE 3221.1.1 Compare and contrast various historical models of the atom.
CLE 3221.1.2 Analyze the organization of the modern periodic table.
CLE 3221.1.3 Describe the atom in terms of its composition and electron characteristics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3221.1.1** Identify the contributions of the major atomic theorists: Neils Bohr, James Chadwick, John Dalton, Max Planck, Ernest Rutherford, and J.J. Thomson.
- ✓**3221.1.2** Compare the Bohr model and the quantum mechanical electron-cloud models of the atom.
- ✓**3221.1.3** Draw Bohr models of the first 18 elements.
- ✓**3221.1.4** Interpret a Bohr model of an electron moving between its ground and excited states in terms of the absorption or emission of energy.
- ✓**3221.1.5** Use the periodic table to identify an element as a metal, nonmetal, or metalloid.
- ✓**3221.1.6** Apply the periodic table to determine the number of protons and electrons in a neutral atom.
- ✓**3221.1.7** Determine the number of protons and neutrons for a particular isotope of an element.
- ✓**3221.1.8** Explain the formation of anions and cations, and predict the charge of an ion usually formed by the main-group elements.
- ✓**3221.1.9** Sequence selected atoms from the main-group elements based on their atomic or ionic radii.
- ✓**3221.1.10** Sequence selected atoms from the main-group elements based on first ionization energy, electron affinity or electronegativity.
- ✓**3221.1.11** Determine an atom's Lewis electron-dot structure or number of valence electrons from an element's atomic number or position in the periodic table.
- ✓**3221.1.12** Expresses an atom's electron arrangement in terms of orbital notation, electron configuration notation, and electron-dot notation.
- ✓**3221.1.13** Compare s and p orbitals in terms of their shape, and order the s, p, d and f orbitals in terms of energy and number of possible electrons.

State Performance Indicators

SPI 3221.1.1 Compare and contrast the major characteristics of various models of the atom: Democritus, Thomson, Rutherford, Bohr, and the quantum mechanical model.

SPI 3221.1.2 Use the periodic table to describe an element's atomic makeup.

SPI 3221.1.3 Describe the trends found in the periodic table with respect to atomic size, ionization energy, electron affinity or electronegativity.

SPI 3221.1.4 Determine the Lewis electron-dot structure or number of valence electrons for an atom of any main-group element, given its atomic number or its position in the periodic table.

SPI 3221.1.5 Represent an electron's location in the quantum mechanical model of an atom in terms of the shape of electron clouds (s and p orbitals in particular), relative energies of orbitals, and the number of electrons possible in the s, p, d and f orbitals.

Standard 2 – Matter and Energy

Conceptual Strand 2

The properties of matter determine how it interacts with energy.

Guiding Question 2

What is the relationship between matter and energy?

Course Level Expectations

CLE 3221.2.1 Investigate the characteristic properties of matter.

CLE 3221.2.2 Explore the interactions between matter and energy.

CLE 3221.2.3 Apply the kinetic molecular theory to describe solids, liquids, and gases.

CLE 3221.2.4 Investigate topics associated with the gaseous state.

CLE 3221.2.5 Discuss phase diagrams of one-component systems.

Checks for Understanding (Formative/Summative Assessment)

✓**3221.2.1** Identify a material as an element, compound or mixture; identify a mixture as homogeneous or heterogeneous; and/or identify a mixture as a solution, colloid or suspension.

✓**3221.2.2** Identify the solute and solvent composition of a solid, liquid or gaseous solution.

✓**3221.2.3** Express the concentration of a solution in units of ppm, ppb, molarity, molality, and percent composition

✓**3221.2.4** Describe how to prepare solutions of given concentrations expressed in units of ppm, ppb, molarity, molality, and percent composition.

✓**3221.2.5** Investigate factors that affect the rate of solution.

✓**3221.2.6** Describe how to prepare a specific dilution from a solution of known molarity.

✓**3221.2.7** Determine the colligative properties of a solution based on the molality and freezing point or boiling points of the solvent.

✓**3221.2.8** Use a solubility graph, composition of a solution and temperature to determine if a solution is saturated, unsaturated or supersaturated.

- ✓**3221.2.9** Classify properties and changes in matter as physical, chemical, or nuclear.
- ✓**3221.10** Use calorimetry to: identify unknown substances through specific heat, determine the heat changes in physical and chemical changes, determine the mass of an object, and determine the change in temperature of a material.
- ✓**3221.2.11** Perform heat of solvation, heat of reaction, heat of formation calculations.
- ✓**3221.2.12** Perform heat of phase change calculations.
- ✓**3221.2.13** Use particle spacing diagrams to identify solids, liquids, or gases.
- ✓**3221.2.14** Distinguish among the solid, liquid, and gaseous states of a substance in terms of the relative kinetic energy of its particles.
- ✓**3221.2.15** Use a phase diagram to correlate changes in temperature and energy with phases of matter.
- ✓**3221.2.16** Graph and interpret the results of experiments that explore relationships among pressure, temperature, and volume of gases.
- ✓**3221.2.17** Solve gas law problems.

State Performance Indicators

- **SPI 3221.2.1** Distinguish among elements, compounds, solutions, colloids, and suspensions.
- **SPI 3221.2.2** Identify these properties of a solution: solute and solvent in a solid, liquid or gaseous solution; procedure to make or determine the concentration of a solution in units of ppm, ppb, molarity, molality, percent composition, etc.; factors that affect the rate of solution; and colligative properties.
- **SPI 3221.2.3** Classify a solution as saturated, unsaturated or supersaturated, based on its composition and temperature and a solubility graph.
- **SPI 3221.2.4** Classify a property of change in matter as physical, chemical, or nuclear.
- **SPI 3221.2.5** Compare and contrast heat and temperature changes in chemical and physical processes.
- **SPI 3221.2.6** Investigate similarities and differences among solids, liquids and gases in terms of energy and particle spacing.
- **SPI 3221.2.7** Predict how changes in volume, temperature, and pressure affect the behavior of a gas.

Standard 3 – Interactions of Matter

Conceptual Strand 3

Interactions between matter generate substances with new physical and chemical properties.

Guiding Question 3

What types of interactions between matter generate new substances?

Course Level Expectations

- **CLE 3221.3.1** Investigate chemical bonding.
- **CLE 3221.3.2** Analyze chemical and nuclear reactions.

CLE 3221.3.3 Explore the mathematics of chemical formulas and equations.
CLE 3221.3.4 Explain the law of conservation of mass/energy.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3221. 3.1** Determine the type of chemical bond that occurs in a chemical compound
- ✓**3221.3.2** Differentiate between ionic and covalent bond models.
- ✓**3221.3.3** Identify and give the chemical formulas of common chemical compounds.
- ✓**3221.3.4** Use a table of polyvalent cations and polyatomic ions to name and describe the chemical formula of ionic compounds.
- ✓**3221.3.5** Convert percent composition information into the empirical or molecular formula of a compound.
- ✓**3221.3.6** Apply information about the molar mass, number of moles, and molar volume to the number of particles of the substance.
- ✓**3221.3.7** Write a balanced equation for a chemical reaction.
- ✓**3221.3.8** Classify a chemical reaction as composition, decomposition, single replacement, double replacement, and combustion.
- ✓**3221.3.9** Use activity series or solubility product table information to predict the products of a chemical reaction.
- ✓**3221.3.10** Predict the products of a neutralization reaction involving inorganic acids and bases.
- ✓**3221.3.11** Balance a chemical equation to determine molar ratios.
- ✓**3221.3.12** Convert between the following quantities of a substance: mass, number of moles, number of particles, and molar volume at STP.
- ✓**3221.3.13** Solve different types of stoichiometry problems, e.g., volume at STP to mass, moles to mass, molarity, etc.
- ✓**3221.3.14** Determine the amount of expected product in a lab activity and calculate percent yield.
- ✓**3221.3.15** Calculate the amount of heat lost or gained by a substance based on its mass, change in temperature, and specific heat during physical and chemical processes.
- ✓**3221.3.16** Research applications of thermal changes in nuclear reactions.
- ✓**3221.3.17** Identify a substance as an acid or base based on its formula.
- ✓**3221.3.18** Investigate the acidity/basicity of substances with various indicators.
- ✓**3221.3.19** Write the nuclear equation involving alpha or beta particles based on the mass number of the parent isotope and complete symbols for alpha or beta emissions.
- ✓**3221.3.20** Determine the half-life of an isotope by examining a graph or with an appropriate equation.
- ✓**3221.3.21** Write a balanced nuclear equation to compare and contrast nuclear fusion and fission.
- ✓**3221.3.22** Describe the benefits and hazards of nuclear energy.

State Performance Indicators

SPI 3221.3.1 Analyze ionic and covalent compounds in terms of their formation, names, chemical formulas, percent composition, and molar mass.
SPI 3221.3.2 Identify the reactants, products, and types of different types of chemical reactions (composition, decomposition, double replacement, single replacement, combustion).

SPI 3221.3.3 Predict the products of a chemical reaction.
SPI 3221.3.4 Balance a chemical equation to determine molar ratios.
SPI 3221.3.5 Convert among the following quantities of a substance: mass, number of moles, number of particles, molar volume at STP.
SPI 3221.3.6 Identify and solve stoichiometry problems (volume at STP to mass, moles to mass, molarity, etc.).
SPI 3221.3.7 Classify substances as acids or bases based on their formulas and how they react with various indicators.
SPI 3221.3.8 Describe radioactive decay through a balanced nuclear equation and through an analysis of the half-life concept.
SPI 3221.3.9 Compare and contrast nuclear fission and fusion.
SPI 3221.3.10 Relate the law of conservation of mass/energy to thermal changes that occur during physical, chemical or nuclear processes.